nary temperature, causes its decomposition into "triphenylmethyl," $(C_6H_5)_3C$.

An investigation of the ethanes containing a smaller number of phenyl groups, from one up to five, would obviously be calculated to throw light on these points. This work has been carried out and it has been found that a very stable compound, which was formerly regarded as being hexaphenylethane, actually possesses a different constitution. It has also been shown that, in certain respects, there is a decrease in stability and an increase in chemical reactivity as the number of phenyl groups in the ethane molecule becomes greater. Thus, for example, pentaphenylethane, $(C_6H_5)_3C \cdot CH(C_6H_5)_2$ is decidedly less stable than tetraphenylethane, $(C_6H_5)_2CH \cdot CH(C_6H_5)_2$.

The final link in the chain of proof has been furnished by Schlenk, who has just shown that if the pentaphenylethane be heated with a neutral solvent of high boiling point, it is decomposed into triphenylmethyl and tetraphenylethane, in the manner indicated by the dotted line in the formula,

$$(C_6H_5)_3C \quad CH(C_6H_5)_2;$$

the tetraphenylethane results, of course, from the combination of two of the groups, $CH(C_6H_5)_2$. It follows, therefore, that there is no difference, in principle, between the behavior of pentaphenylethane and hexaphenylethane towards solvents; when in solution, both give triphenylmethyl, the latter at the ordinary temperature, the former only when it is heated.

In view of these results there is no ground for doubting that the colorless solid obtained by Gomberg is really hexaphenylethane, $(C_6H_5)_3C \cdot C(C_6H_5)_3$, and that its passage into solution, at the ordinary temperature, suffices to resolve it into two molecules of colored triphenylmethyl, $(C_6H_5)_3C$.

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SPECIAL ARTICLES

SUGGESTIONS AS TO THE CULTURE OF BUTTERFLIES

BUTTERFLIES, with their clear-cut color patterns and brilliant hues, their remarkable polymorphism seen in the occurrence within a single species of two or more seasonal forms, or of melanic, albinic or other varieties often limited to individuals of one sex, furnish a most inviting field for the student of evolution and heredity. The fact that in America, at least, no precise and long-continued work on heredity in diurnal lepidoptera has been undertaken hitherto is probably due in part to the belief that the mating of butterflies, occurring usually in the air, would be difficult to bring about in small cages; though the mating of moths under such conditions is generally known to be an easy matter. It is my purpose in this article to correct this false impression in regard to the mating of butterflies, and to make other suggestions as to methods of caring for this dainty live stock, of marking individuals to indicate their pedigree, and of preserving them in a more compact, permanent, convenient fashion than the usual impalement on long pins in bulky drawers or boxes.

One who undertakes the study of the heredity of butterflies may of course begin either with live wild females, presumably already impregnated, or with eggs already laid, with larvæ, or with chrysalids. For transportation over long distances chrysalids, or eggs upon the food plant, are usually to be prefered. Living plants with roots intact and leaves covered with eggs may be shipped in tin boxes by mail. But often only the imago can be obtained. In this case, and always, if the distance is not too great, sending live butterflies by mail in strong, cylindrical tin boxes lined with moist blotting paper that is held firmly in position is to be recommended. I have found that *Colias philodice*, shipped 150 miles in this way, and shut up closely for eighteen hours, stands the journey well, and lays abundantly, if well fed with sweetened water upon arrival.

For purposes of identification it is of course necessary for the student of heredity to label each living adult butterfly. This is readily done by writing the sign of the family and individual with pen and ink upon the under

surface of the hind wings. Since aqueous ink will not flow readily enough, the pigment used should be dissolved in 50 per cent. alcohol, and applied with light strokes of a stub pen. Anilin dyes are convenient, as they are readily soluble and can be obtained in almost any color, but for general use any carbon ink that is not precipitated by mixing with 50 per cent. alcohol is preferable, because more permanent. The live butterfly, held firmly with smooth-tipped entomologists' forceps clasped across the fore and hind wings close to the body, objects very little to light strokes of the pen, and the alcoholic ink dries quickly.

For the designation of a family from a single mating, that is, the progeny of one female, I use a small letter, reserving the corresponding large letter for the original wild female. The individuals of each family as they pupate, or, if more convenient, as they emerge from the chrysalis, are marked with arabic numerals written at the right of the family letter, like an exponent. In butterflies of course these numbers may run up to over 100. In one family of *Colias philodice* that I raised during the season of 1910 there were 123 brothers and sisters. Suppose this family were the offspring of the wild female, "A," and were called "a." The last to pupate (or to emerge) would be "a^{123}." To facilitate the handling and recording of large families, it is sometimes well to raise the successive batches of eggs laid by a single female separately, designating each successive lot with a numeral written as a coefficient, so that $2n^{10}$ would mean the tenth butterfly to pupate (or to emerge) in the second lot of eggs laid by the mother of family "*n*." The name and pedigree of this female, and that of her mate, would be recorded, of course, at the head of the sheets on which the dates of pupation and eclosion of their offspring are set down.

No elaborate outdoor quarters are needed for keeping and mating live butterflies. The air of the laboratory needs only to be fresh and fairly moist, as that of the ground-floor rooms of large buildings of brick or stone is likely to be in summer. The parched air of a steam-heated room, or of one upon an upper floor and flooded with direct sunlight, is more fatal to butterflies than complete absence of food in a moist atmosphere. Bottomless cages 15 inches in length and breadth and 10 inches high, consisting of a simple frame of pine strips covered inwardly with cotton mosquito netting, are of ample size for *Colias philodice,* serving as a vivarium for the pupæ, as an enclosure for mating, and as a cage for the female during egg-laying, if the food plant is small enough to be covered by a frame of this size. The use of wire screening is not to be recommended for adult butterflies, as it soon wears out and disfigures the wings that beat upon it. A frame of this sort covered with cheese cloth, or better with the material known by milliners as frame covering, makes an excellent breeding cage for even the youngest larvæ.

The imago that has just crawled up from its chrysalis rests until the blood flows from the abdomen into the tiny pupal wings. In *Colias philodice* this requires about five minutes, but the wings after reaching full size remain limp for about a half hour; and marking should be deferred until they harden. Then the males of each family may be placed together in one cage, the females in another. On the day following eclosion they will be ready to feed, and bouquets moistened with a solution of honey and water, or brown sugar, should be placed in the cages.

It is surprising to a beginner to see how readily live butterflies may be handled in the absence of direct sunlight or intense diffuse light. Even out of doors, after sunset or in the early morning, they may be allowed to creep upon the finger wet with sweetened water, and feed. They are attracted by a warm moist hand, as by a flower, and on holding them by the costal margin of the wings with one hand, and allowing them barely to touch with the feet a moist finger or palm of the other, they may be stimulated to extend the tongue and begin feeding. Once feeding has begun, they may be moved to a generous drop of honey and water and allowed to drink their fill. In dull, cold weather butterflies neither feed nor lay, and it is necessary in midsummer, when metabolism is rapid, that

individuals to be used in breeding should have at least one square meal a day, served either in the early morning or evening, when they can be handled without danger of escape. In case they are actively flying during the day, and visit the moistened bouquet provided for them, they will of course feed themselves, but they are more strongly attracted toward the source of light than toward food, so that, if only slightly active, they may not reach the food supply at all. This is one reason against the use of large cages. They do not go in search of food, as the bee seems to do, but, stimulated by light to activity, they find it almost by accident. Hence they must be kept near the food.

The same reason applies to the use of small cages for mating. The larger the cage, the smaller are the chances that two individuals will meet. I began my experiments by turning butterflies loose in a large screened veranda, strongly lighted only on one side. Under such conditions their attraction towards the light absolutely controlled them. Each went his or her own way, paying not the slightest attention to the others. If several males and females of the same species are placed in a cage of the dimensions noted above (10 inches high and 15 inches square) or 15 inches in all three dimensions, and kept in the direct sunlight, or, if the temperature is high enough, in strong diffuse light, some matings may be expected. As soon as a couple are mated they should be removed to a separate cage, and their numbers noted. Mating continues in *Colias philodice* for over an hour, usually for about an hour and a half, and often two or three hours, so that there is little danger of promiscuity when large numbers of both sexes are placed in the same cage, if properly watched. One male often can be mated on successive days with several females.

Fertilized females often begin to lay on the day after mating. They will lay quite well indoors under warm, sunny conditions, provided they are well-fed, but in any case the food plant on which they lay should be growing, so that the minute larvæ, upon hatching, will find fresh food awaiting them. The most convenient way to obtain the eggs and rear the larvæ of *Colias philodice,* for example, is to place the butterfly in a cage over healthy clover growing on a lawn that is free from ants and slugs.

The food plants and feeding habits of larvæ are so varied that few general directions can be given for their care. Caterpillars that feed on coarse leaves that wilt slowly when gathered may be kept in large, flat, cloth boxes, like those that are used at the Gypsy and Brown-tail Moth Laboratory at Melrose Highlands, Mass. But the leaves of most food plants of butterflies soon become wilted and dry under such conditions, and it is preferable to enclose the growing plant in a cage, or a branch of the shrub or tree in a bag of cheese cloth. If kept in close glass vessels to prevent evaporation, or even in large moist vivaria, there is danger in *Colias philodice,* at least, of infection with an intestinal bacterial disease that may kill a large proportion of both larvæ and pupæ. So a good general rule is to keep the larvæ upon their food plant out-of-doors, and well screened from insect parasites and birds.

Pupæ should be carefully guarded from mice and slugs, and if either are at all abundant the chrysalids should be taken indoors. *Limax maximus* will gnaw through a fine cloth netting on the inside of which a pupa rests, and eat the chrysalis, leaving a small hole through the screen, the margin of which is blackened with the salivary juices of the slug, which apparently contain sulphuric acid.

The student of the genetics of butterflies will hardly be content with the ordinary museum methods of mounting specimens upon pins stuck into cork. Greater compactness, perfect safety from museum pests, and quick accessibility to both surfaces of the wings are needed. The patent Denton mounts for individual specimens satisfy these requirements well, but they are expensive for use in large numbers and, though vastly superior to the ordinary pin-cushion method, are not convenient to handle when huge families are being examined and compared, because each specimen must be picked up separately. All these needs, however, are met by a simple form of

case which the present writer has used with much satisfaction.

The mount consists of a rectangular, wooden frame of any desired size (*e. g.*, 10×12 inches) made of pine strips three eighths of an inch square in thickness, mitered or mortised at the corners, holding apart two sheets of glass corresponding in size to the outer edge of the frame, one for the top and one for the bottom of the mount, which is bound together with passe-partout $1\frac{1}{4}$ inch wide. As for the glass, old photographic plates, 10×12 inches in size, cleaned with caustic potash solution, are convenient in dimensions, thin and light, and of good quality.

Each butterfly is prepared by stretching and drying it upon its dorsal surface, pinning it temporarily until it has been made fast with strips of paper. The wings of the dried specimen must lie flat, or be inclined slightly ventrad, but never dorsad. It is then fastened, with a small drop of thin liquid glue applied to the dorsal surface of the thorax, to the sheet of glass that is used as the upper pane or cover. Small strips of sheet lead (about 1 inch $\times$ $1\frac{1}{2}$ inches), bent into an arch, make a convenient weight to set astride the wings until the specimen is well fastened to the glass. The pane is then inverted over the frame, and glued to it. The lower sheet should not be glued to the frame, but fastened to it only by the strip of passe-partout, $1\frac{1}{4}$ inch wide, which is used to hold the two panes of glass together and seal the mount. If a specimen should get loose, the bottom glass may be easily cut away, repairs made, and the case sealed with fresh passepartout. If the upper pane should get broken, it is a simple matter to remove the specimens, using steam when necessary, and remount them. Care should be taken in the preliminary stretching of the specimens lest the feet should project more than necessary, so that, when the case is put together, they come into contact with the lower plate, and loosen the attachment to the upper. For ordinary purposes, however, it is only necessary to trim off the tips of a few that project excessively.

Seven hundred butterflies of the size of *Colias philodice* can be filed away in the space of a single cubic foot, in the mounting frames just described, each case measuring 10×12 inches in breadth and length and one half inch in thickness, and containing 25 specimens. They are sealed from dust and vermin, and easily examined on both surfaces in groups of convenient size.

A rich field for conquest awaits any one who chooses to leave the beaten tracks of entomology and scout among the fastnesses of experimental evolution. When one considers the remarkable results that have been accomplished single handed by such observers as Standfuss, Tower, Doncaster and T. H. Morgan, not to mention many others, the possibilities achieved in this field if the huge army of observers already interested in insects should attack in an organized way the problems of variation, the inheritance of acquired characters, mutation and natural selection, polymorphism and sex, mimicry and protective resemblance, can hardly be overestimated. Desultory observations of the strolling naturalist will not help much in this conquest, but long-continued breeding of carefully selected strains under well-controlled conditions can not fail to win valuable results.

Entomological societies and journals of the future, in order to contribute effectively to the real advancement of science should organize cooperative plans of research along these lines, and enlist the services of the countless observers whose random notes now fill their archives.

John H. Gerould

Variegation of European Alfalfas

As a part of the extensive investigations being conducted with alfalfa at the Dickinson, North Dakota Sub-station, a series of European alfalfas was planted in the nursery in 1909. A study of some of the plants in 1910 revealed the presence of variegation in flower coloring. This was expected to a certain extent. As a preliminary to the determination of the correlation of the variegation to other characters, both physiological and morphological, the percentage of variegation was determined for each strain or planting.